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Technology-enhanced learning as a site for interdisciplinary research

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Conole, Grainne; Scanlon, Eileen; Muddin, Paul and Farrow, Robert (2010). Technology-enhanced learning as a site for interdisciplinary research. Technology Enhanced Learning Research Programme; Economic and Social Research Council; Institute of Education, London.

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Version: Version of Record

Link(s) to article on publisher's website:
<http://www.tlrp.org/docs/TELInterdisciplinarity.pdf>

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Preface



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This briefing on Interdisciplinary Research is the fifth publication of its kind emerging from the Technology Enhanced Learning Research programme (TEL). TEL is a £12m programme running from 2007-2012 with eight large interdisciplinary projects aiming to combine technological and pedagogical expertise to improve outcomes for learners. The programme is funded jointly by the UK's Economic and Social Research Council and Engineering and Physical Sciences Research Council. TEL also commissions analyses of key theoretical, practical and policy issues across and beyond the eight projects, and in the wider TEL field.

Achieving productive interaction and cohesion between researchers from diverse disciplines is one of TEL's central challenges and potentially the source of one of its most meaningful contributions to the field. In facilitating the development of a new field of TEL researchers who are fluent in both the pedagogical and technological facets of research, we can maximise the potential for technology to enhance outcomes for learners.

This document is a significant step on that road, laying out the issues and opportunities of the current situation and suggesting future paths towards making truly interdisciplinary research possible.

We welcome comments and feedback via the TEL website, www.tlrp.org/tel

A handwritten signature in black ink, appearing to be 'R. Noss'.

Richard Noss
TEL Director
London Knowledge Lab

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Executive summary

Technologies are becoming increasingly sophisticated and offer more and more powerful potential. As a result, Technology-Enhanced learning (TEL) research is now a vibrant area exploring the ways in which technologies can be used for learning and uncovering some of the challenges and issues associated with their use. Tackling these issues requires a multi-faceted approach and hence, not surprisingly, much research work in this field is interdisciplinary. This research briefing considers the nature of interdisciplinarity in TEL research. It is based on an extensive literature review, along with interviews with 18 researchers in the field. Further details about the background to this work are available (<http://cloudworks.ac.uk/cloudscape/view/1954>), along with a more detailed report with quotes from the interviews and references (<http://cloudworks.ac.uk/cloud/view/3419>) and via www.tlrp.org/tel.

The briefing begins by considering the changing context of TEL research and in particular some of the possibilities and challenges technologies present. The term *interdisciplinarity* is discussed and some of the perceived benefits of adopting this research approach are given. Drawing in particular on the insights gained from the TEL researchers in the interviews, the nature of TEL as a research field is considered, including its feeder disciplines, theoretical perspectives and methodological approaches. The ways in which technologies are used by TEL researchers is then considered, and in particular how this influences the ways in which they carry out their work. Challenges are then discussed, along with suggested strategies for fostering interdisciplinary approaches.

The ten key messages are:

1. Technologies continue to develop at a phenomenal pace, and have clear potential for use in learning. However understanding how technologies can be used and how learners and teachers are co-evolving their practice through the use of technologies is complex. Interdisciplinarity offers a logical means of tackling such 'wicked' research questions.
2. TEL is itself an inherently interdisciplinary field. Researchers are drawn from a broad range of research disciplines, bringing with them a rich set of theoretical perspectives and methodologies.
3. TEL researchers use a rich range of technologies to support their research activities, both in terms of data collection and analysis. For some, use of the tools is utilitarian, for others researching with and through the technologies is core to their practice.
4. New technologies and in particular tools for social mediation and open, participatory sharing are changing the way in which research work in the field is communicated and disseminated. Newer channels, such as blogs, wikis and social networking tools, are challenging traditional channels of publication. This raises tensions between traditional notions of what constitutes valid research output, about how research is peer reviewed and assessed, and tensions between the need to communicate research findings in a fast and effective manner versus the need to ensure standards of academic rigour are maintained.
5. Technologies provide the potential to break down disciplinary boundaries, by making research findings more visible across a wider research audience. The variety of mechanisms for representing and communicating research work provide a rich network of mediating artefacts that researchers can interrogate and interpret.

6. There are many benefits to adopting an interdisciplinary approach. The strengths of bringing different discipline perspectives to bear on a research problem, exposing researchers to alternative research perspectives, literatures and methodologies, all provide opportunities for researchers to develop shared understand and adopt more reflexive approaches to research practice.
7. Undertaking true interdisciplinary research is challenging and often in reality the collaboration between disciplines is only surface level. A number of strategies can be adopted to overcome this: allowing time to develop a shared understanding and common vocabulary, ensuring that research projects are clearly articulated and shared with the research team, developing effective communication mechanisms and means of recording shared understanding across the team.
8. Undertaking true interdisciplinary research opens up the potential for the development of new theoretical insights and methodological innovations, by bringing different discipline perspectives together to address a particular research problem.
9. Current organisational structures and cultures, and policy directives are barriers to fostering interdisciplinarity. Discipline specialisation is embedded in much academic practice; organisational structures, roles and processes are demarcated by discipline. Similarly academic recognition is through contribution to established publications, and via peer validation by others in the same discipline. Interdisciplinary publications are seen as less prestigious.
10. Interdisciplinarity is key to the successful future of TEL research. It is important that as a community we work harder at fostering interdisciplinarity and making it work. Some strategies for achieving this have been described here, but it will also be necessary to provide the time and space for researchers to become encultured into interdisciplinary practices and there is a need for changes at policy level too, to recognise and reward this type of research.



The changing context of research

The impact of the Internet on working practices and the way we share information and communicate has been profound. Recent web 2.0 technologies appear to be leading to a similar seismic shift in patterns of user behaviour – in terms of how people communicate, collaborate and network, and in terms of the perceptions of content in a world where it is free and multi-faceted (Conole and Alevizou, 2010). This leads to new challenges for the delivery of education across technological platforms in their many guises (TEL, Networked Learning, e-Learning, Learning Technology, and Virtual Learning Environments). Consequently, there has also been a growth in research into the use of technology in education to meet these challenges. This has drawn together research teams from many disciplines, including educationalists, computer scientists, psychologists, information scientists, and educational technologists, as well as subject matter experts.

In parallel, increasing prominence has been given to interdisciplinarity as a means of addressing cross-discipline research challenges, where researchers from two or more disciplines bring their approaches and adapt them to form a solution to a new problem. Indeed, interdisciplinarity has become increasingly important as a means of attempting to address complex, real-world research problems and grand challenges. This is particularly true of research concerned with the use of technology for learning and teaching, which by its nature brings together researchers from different discipline perspectives (education, computer science, psychology, information science, etc).

This is evident in recent policy rhetoric, which encourages greater use of technologies to support learning. However, to what extent is this vision grounded in existing practices in research, teaching and learning? What is the nature of interdisciplinarity in TEL research? What are the perceived benefits and the identified challenges? What strategies can be put in place to promote better interdisciplinary approaches? These are some of the key questions that are addressed in this report. A more detailed report from which this is derived is also available (Conole et al., 2010), which includes details of a literature review and discussion of 18 interviews carried out with key TEL-researchers, which form the basis of evidence for the topics discussed here.



The benefits of interdisciplinary working



Whilst the purpose of working in an interdisciplinary manner from a research project perspective is to provide new solutions to new problems from across disciplines, there are personal and academic benefits as well (a certain kind of intellectual curiosity, understanding how other disciplines think, different rich theoretical and methodological perspectives and looking at the same shared problem space from different eyes). A number of benefits of doing interdisciplinary research are evident. Firstly, that it pushes the researchers intellectually; it helps broaden mindsets and encourages thinking laterally or 'out of the box'. Secondly, it enables researchers to do things that they couldn't do on their own; researchers interact with and learn from other people and their skills set, drawing on the strengths and different armoury of tools they bring from their different discipline perspectives. Finally, becoming aware of other discipline perspectives helps broaden a researcher's literature base and may give rise to fresh theoretical insights. Interdisciplinarity therefore is reflexive by nature.

Whilst it is evident that these benefits are hard to quantify, once researchers start to cross disciplinary boundaries people become exposed to different ways of doing things e.g. different terminologies, methodologies, tools and literature. The benefit is that, following such exposure, it is possible that the individual's own ideas start to adapt. In other words, by working with people in other disciplines an individual starts to add quite different slants to their own interpretation of their own discipline. The overall positive impact upon interdisciplinarity practices is that once a researcher has successfully worked in an interdisciplinary team, they are more likely to champion and further interdisciplinary working.

These personal benefits are also reflected in terms of both product and process benefits. There are benefits in having contributions from people across multiple disciplines for the 'product' that is developed. But there is also a process benefit in terms of shared understanding of how to work in an interdisciplinary fashion. Interdisciplinarity working can provide a much richer research output than disciplinary or multidisciplinary working. It can also result in the production of many more papers published in a wider variety of journals, resulting in a greater dissemination of the research. It similarly makes the working on the project a learning process in its own right. There is always a possibility that individual researchers might be inspired to make a theoretical breakthrough from having experienced different disciplinary worlds.

Origins and career trajectories of TEL researchers



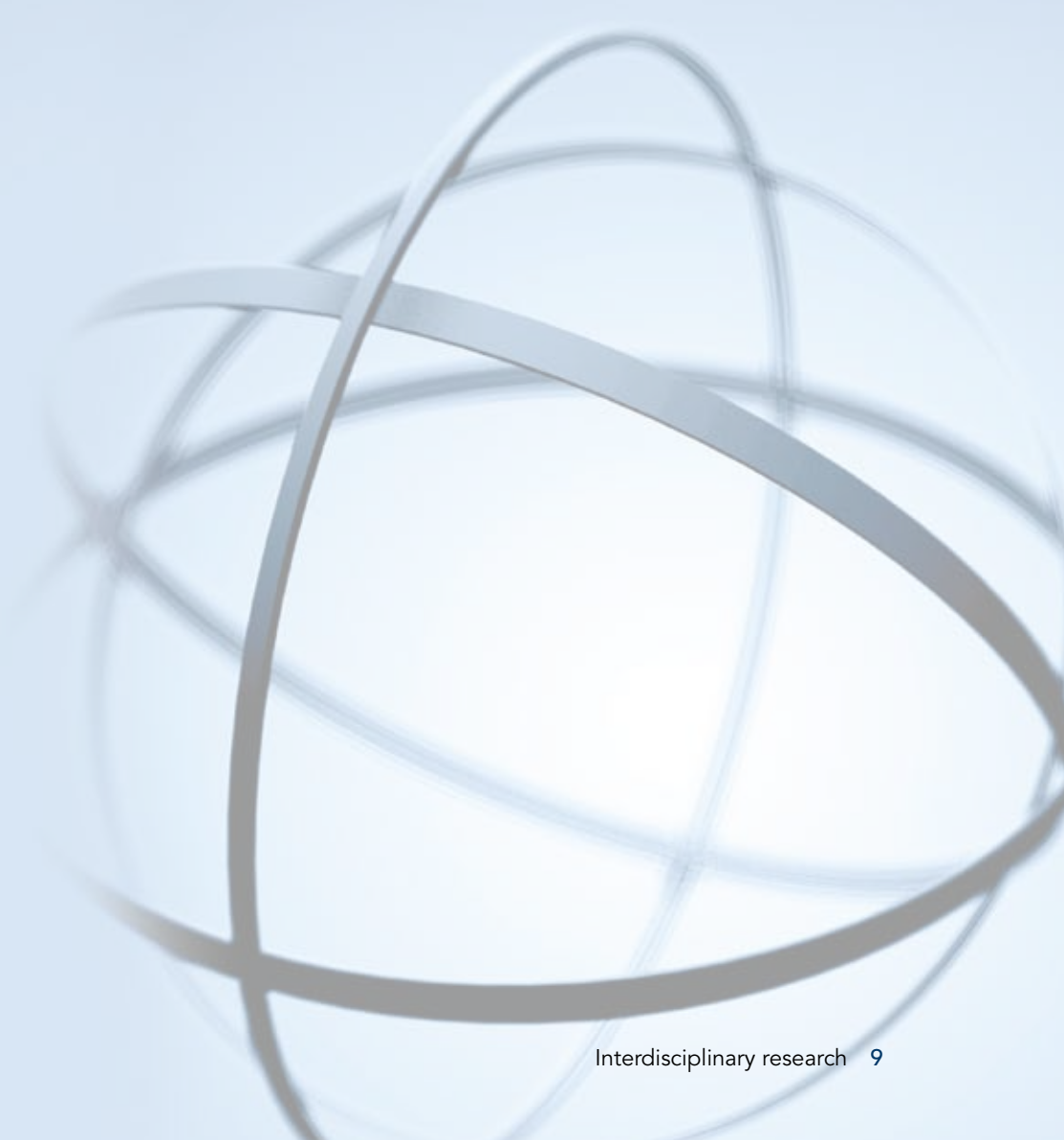
The eighteen TEL researchers interviewed came from diverse discipline backgrounds. Collectively therefore, the TEL field is drawing on a rich range of theoretical perspectives and methodologies. For some in the field, their original discipline is important in terms of shaping their research approaches; others see this as less important. The value of the 'home' discipline seemed to centre on the ways in which it helped the individual frame their thinking – seeing patterns, oscillating between textual, mathematical and visual representation and making sense out of complexity. The tension between the individual discipline perspectives and the holistic cognitive skills necessary for an interdisciplinarity mindset is clear, TEL researchers recognise the need to both draw on – and move beyond – their original disciplines; Spelt et al argue (2009) that interdisciplinary thinking is a complex cognitive skill. Alignment with their conceptions and views of the world from their background within the context of doing TEL research is at the heart of much of what defines TEL interdisciplinarity. Furthermore, many TEL researchers believe that, broadly construed, education is necessarily an interdisciplinary endeavour and therefore researchers in the field need to adopt an interdisciplinary approach to TEL.

When asked about the distinctiveness of interdisciplinarity, a number of themes emerged.

1. As a relatively new field, TEL research has attracted people from different disciplines, each bringing with them different theoretical and methodological perspectives.
2. TEL research by its nature is complex, and is concerned with improving education through use of technology – it therefore needs to draw both on subject areas concerned with learning and teaching (education, psychology, etc.) and those concerned with technology (computer sciences, information sciences etc.), as well as understanding the local nuances and cultural differences across different subject domains. Bringing these different aspects together effectively is a key challenge of TEL research and therefore it needs the different interdisciplinary perspectives to understand it; i.e. *interdisciplinarity is a core facet of TEL research*. If TEL research is going to work, it has to be interdisciplinary and people need to bring a wide range of different skills, perspectives and research tools to bear upon a particular problem. Many felt that interdisciplinary approaches to TEL research were superior to single discipline approaches because they bring together a productive mixture of perspectives and encourage debate.
3. There are huge and interesting cognitive, technical and social questions surrounding the delivery of TEL. For example, how should the cognitive and the social be integrated? How should knowledge be organised? How should classroom practice be managed? These are highly complex questions and need more technical resources than other areas of educational research. Indeed, a common theme across the interviews was the opinion that you cannot do a TEL project without lots of multi-disciplinary and interdisciplinary expertise. Also the products or artefacts produced then need an interdisciplinary approach to evaluation.
4. A number of strategies need to be in place to support TEL research practices. Researchers need to be helped to develop the skills needed to undertake interdisciplinary research. Institutions need

to have in place appropriate career paths to foster and promote interdisciplinarity. This has not always been the case and some TEL researchers have found that they had reached a ceiling in their institution in terms of promotion, having to either revert to more traditional roles/job titles or move into managerial positions. It was felt that often the value of TEL research groups in terms of institutional support remains to be fully exploited and, that interdisciplinary research groups could be playing a more proactive role within institutions, helping them make strategic decisions on the effective use of technologies to support learning and teaching. It seems that TEL research groups often find themselves outside formal institutional decision-making mechanisms.

5. Some tensions were evident between the disciplines. TEL research has to meet the research agenda of the disciplines involved, and, in particular, the needs of both computer scientists and educationalists. Some TEL researchers feel that, historically speaking; educational technology/TEL research has been dominated by the educationalists. There remains a tension between technologists and educationalists because of this alleged dominance. There is also an inherent tension between the level of precision needed from a computer science perspective and the less well-defined nature normally associated with educational design, where design is more based on practice and experience than rules and methods.



Influences, beliefs and theoretical perspectives

There appears to be a common shared discourse underpinning the TEL research field, around Socio-cultural approaches – in particular the work of Vygotsky (1978), Engeström (1987) and others on Activity Theory. Texts widely cited are listed in the full report. This list give a flavour of what some researchers cite as their influence and the broader literature that is being drawn on. It demonstrates that the field is indeed interdisciplinary, because these texts are drawn from a broader set of disciplines, than research that can be purely labelled 'TEL'. However, there is an additional important aspect to the nature of interdisciplinarity in TEL research, both in terms of the actual processes involved and how individuals react with and benefit from the other researchers. However for many of the TEL researchers interviewed, it is the nature of interdisciplinary working itself that was more influential in the way they worked, rather than either a specific person or text.

TEL researchers recognise the need to bring background theoretical perspectives to interdisciplinary research to the fore to contextualise the research being undertaken. But they also recognise the challenges of doing this: how can theories be integrated produce a composite perspective?' The potential for new thinking and the emergence of new methodologies, links back to the notion of interdisciplinarity as 'deviant' or 'transgressive' and its ability to challenge existing assumptions (Nowotny, 2001; Moran, 2010). Many TEL researchers believe that interdisciplinary research work is unlikely to be addressed adequately – or fully understood – within a single disciplinary approach, and hence that there is a need for a portfolio of mixed methodologies/methods to be selected for interdisciplinary research. An 'emergent' tradition for interdisciplinary research involving combinations of complementary methods was identified, and interviewees reported experience of such 'mixed method' projects which placed equal value on both qualitative and quantitative approaches (Greene and Caracelli, 1997).

TEL researchers use a diverse range of methods, both qualitative and quantitative (see full report for a list of these). It is evident that an interdisciplinary researcher needs to be open-minded and prepared to engage with many different methods. 'Triangulation of methods' and combining the benefits of both qualitative and quantitative approaches is widely recognised as an important feature of TEL research. However, mixing and combining qualitative and quantitative approaches is not unproblematic and is believed by researchers to be one of the reasons why papers get rejected by journal editors, since there is not always a precedent or a paradigm for the approach adopted. Interdisciplinary researchers cannot always rely on standards of validity from single disciplines, and often have to arrive at their own. Furthermore, deciding which journals to publish interdisciplinary research in is not always straightforward.

Using technologies to foster interdisciplinarity

Perhaps not surprisingly, TEL researchers make extensive use of technologies to support their research practices, but this use is diverse and very much individually appropriated. Some researchers are comfortable with adopting a truly 'web 2.0' open approach to sharing and communicating research findings, others are more cautious. Furthermore, there is a whole spectrum between those that see these technologies as mere tools and those who see experimentation and the exploration of new technologies as a key facet of being a researcher in the field. There does not appear to be a single common toolset across TEL researchers, but overall they tend to be sophisticated technology users, using the

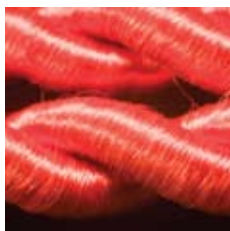
technologies to support all aspects of the research lifecycle from data collection and analysis through to dissemination. TEL researchers have different views on tools. For some they are simply utilities, whereas others have an inherent interest in the tools themselves. They see experimentation and immersion in the tools as part and parcel of being a TEL researcher and hence see it as an important part of their overall research approach. In today's increasingly open and networked technological environment there are new issues in terms of privacy and ethical issues in terms of both using and researching technologies.

In addition to creating and connecting online research communities, these tools offer new possibilities for participatory or collaborative design. Communication technologies are uniquely able to create feelings of interconnectedness and community over geographical distance; making it easier for stakeholders to have their voices heard. Digital repositories and other online tools mean research results can now be made available to a much wider audience than in the past. Open access practices are increasingly evident, whereby researchers are choosing to make their research publications freely available via institutional research repositories; thus challenging traditional publication channels, such as journals and books. Some researchers are even going a step further and advocating the notion of making original, raw data publically available for scrutiny and manipulation by others. The so called 'web 2.0' technologies in particular foster co-construction of knowledge and active user engagement, prompting some researchers to choose these technologies as their preferred mechanism of dissemination over traditional recognised publication routes. Technology offers an obvious way to break down the disciplinary boundaries in traditional academic practice because it is the medium through which research findings are translated into cultural products. Arguably the affordances of new technologies offer something of a step change; providing a wide variety of different ways in which academics can now communicate, collaborate, critique and share knowledge.

However the effective use of new technologies requires new forms of literacy and new uses of technology (Jenkins, 2009), as well as a conscious understanding on the part of the researcher as to what kind of digital identity they want to portray. The suggestion made by Cook-Sather and Shore (2007) is that to remedy the over-specialisation of disciplinary research, we must think of the university 'faculty' as a much wider group – including staff and students – all involved in the same process of knowledge production. Information technologies can help the exchange of ideas and data to remain focused, meaningful and pertinent.

In addition to facilitating communication, technologies can also be use to support the management and analysis of research in a variety of ways. There are now a wealth of software tools for organising and analysing both quantitative and qualitative research data. Clearly such tools are helpful in that they free the researcher from the more mundane aspects of managing data. Arguably, they also change the way in which the researcher is interacting with and hence understanding the data. Technologies also play an important role in terms of broader dissemination of research findings and can be used to assess the impact and dissemination of interdisciplinary research. The printed book or journal article is now just part of a spectrum of different dissemination mechanisms academics can use – blogs, wikis, social networking sites and even Twitter now offer complementary modes of communication. Most importantly these web 2.0 technologies can help spread research findings far more quickly that traditional publication routes. Furthermore because of their inter-connected nature they offer the possibility of ongoing interaction and dialogue between the researcher and the broader community.

Challenges to interdisciplinarity



Despite the fact that the idea of successful interdisciplinarity has become widely accepted across academia, it rarely fulfils its promise in practice and there has been relatively little research into how to foster and promote interdisciplinary research groups. To some extent, this is because academics have tended to remain wedded to their cognate disciplinary mindsets, and rarely embrace the kind of epistemological or methodological holism required of truly interdisciplinary researchers. It is difficult to establish standards of validity across subject domains, and this presents researchers with a challenge as they can lack effective criteria for evaluating or planning interdisciplinary research. Because academic vocabularies and practices are often discipline-specific, there remain real challenges around managing the transition between disciplinary and cultural boundaries. Spelt et al. argue that interdisciplinary thinking is a complex cognitive skill, which integrates disciplinary knowledge to produce a 'cognitive advancement' that would have been unlikely through individual disciplinary means. Thus, interdisciplinarity is integrative, and is associated with 'boundary-crossing skills... for instance, the ability to change perspectives, to synthesize knowledge of different disciplines, and to cope with complexity' (Spelt et al., 2009: 366).

The challenges facing interdisciplinary research include the way that disciplinary norms and a culture of specialisation have been embedded in higher education, the difficulties surrounding any attempt to define interdisciplinarity, establishing alternative forms of peer review, the problem of obtaining consensus among researchers from different disciplines, the need for a common language that can facilitate reaching mutual understanding, and the difficulties of securing financial and institutional support for interdisciplinary research. Achieving effective co-operation between different specialists or organisations thus necessitates effective methods for communication, collaboration and evaluation.

The complexity and diversity of contemporary research means that disciplines are often brought together around a single research question, but disciplinary practices are seldom properly understood outside of the communities within which they usually take place. This is one prominent reason why the familiar mechanisms of disciplinary academia can be so difficult to transcend. It is unreasonable to expect interdisciplinary researchers to master more than one discipline to the same standard that a disciplinary researcher would be expected to attain. Disciplinary experts may be useful for assessing disciplinary contributions, but not the relationships between the contributions of the different researchers, or materials from outside their home discipline: interdisciplinary activities should be "judged on how well they achieve their objectives and how well they integrate knowledge" (Østreng, 2010: 67).

Consequently, interdisciplinary researchers need to engage with complex epistemological and methodological questions about the emergence, status, and validity of knowledge. Since these constitute the background to a given discipline – indeed, to a large extent these are what define a discipline – they are rarely the focus of those who work solely within particular disciplinary boundaries. Lunca (1996) suggests that the shortcomings of most interdisciplinary research may be largely explained with reference to levels of awareness about the kind of cognitive and epistemological commitments made within disciplines. More specifically, there are two issues of particular importance for interdisciplinarity.

1. There is the question of how to generate a procedure for deciding how to approach particular problems that transcend disciplinary borders.
2. It is necessary to find a way of reconciling the disciplinary and interdisciplinary approaches to the research question in order to render them compatible. As a result, researchers can improve the interdisciplinarity of their work by “learning the language of the epistemological, logical and philosophical analysis of their speciality” which “will enable them to enter into interdisciplinary collaboration” (Lunca, 1996: ii-iii). This process, driven by the aim of increasing solvability through translating disciplinary languages, is what Lunca refers to as ‘interdisciplinarisation’ (Ibid.,14).

In addition to these concerns surrounding the inherent academic worth of interdisciplinarity, a number of issues arise because of the traditional structural organisation of universities and how they are managed. On the whole, universities are organised around traditional discipline boundaries and new emerging research fields or those that adopt an interdisciplinary approach do not easily sit within this traditional structure. It seems evident that the future of any successful interdisciplinarity is dependent on the relationships interdisciplinarity studies has with other departments and the administrative structures of the university, particularly in the form of senior managers who can champion and support interdisciplinary research. However, the specific organizational forms that would give interdisciplinarity the best chance for being effective remain unclear.

Institutional structures can (perhaps inadvertently) impede interdisciplinary work. TEL researchers have diverse career trajectories across different discipline boundaries. There is no one common ‘logical’ location for TEL researchers who instead are dispersed across a range of cognate discipline departments or service units. Rarely are there examples of departments genuinely organised around an interdisciplinary approach. In addition, there is an issue about the perceived credibility of interdisciplinary research in comparison to traditional research domains and many of the metrics used to assess research success (such as funding opportunities, prestigious journals, and individual contributions/weightings of research output) actually mitigate against interdisciplinary approaches. This tension was evident in the interviews, where researchers said that it was often easier to revert to publishing in their home discipline journals, where the ‘rules of the game’ were familiar. Trying to cross discipline boundaries and merge different methodological perspectives was extremely challenging. Some researchers felt there were also issues in terms of funding this type of research, interdisciplinary proposals were often judged by those who had a narrow, single discipline view and hence were unable to see the broader picture.

A key issue with interdisciplinary collaborations is that they are situation-specific, and hence unpredictable. Interdisciplinary inquiry is both diverse and highly specialised, and the specialised nature of interdisciplinary study means that it is hard to describe general rules for effective interdisciplinarity. Some disciplines (or combinations of disciplines) are more compatible with each other because they work from similar assumptions. For those interdisciplinary configurations that incorporate less compatible methodologies, however, the problems are compounded. Lattuca suggests that for interdisciplinarity to succeed, we need to revise our definitions of interdisciplinarity and construct a better understanding of interdisciplinary work, especially in light of the claim (Klein, 1990) that the majority of literature on interdisciplinarity is largely anecdotal rather than empirically grounded or epistemologically reflective.

Interdisciplinarity as a means of addressing cross-discipline research is one of the major challenges for investment in TEL research projects. The benefit is perceived as being tackling the issues from

different perspectives, i.e. that researchers from two or more disciplines bring their approaches and adapt them to form a solution to a new problem. Whilst many project teams think they are working in an interdisciplinary way, the reality is they often fail to overcome the challenges that prevent true interdisciplinary working and they remain functioning in a multidisciplinary way. In reality a lot of what is labelled interdisciplinarity, is in fact: 'pseudo- interdisciplinarity' or 'parallel playing', where people work together in teams.

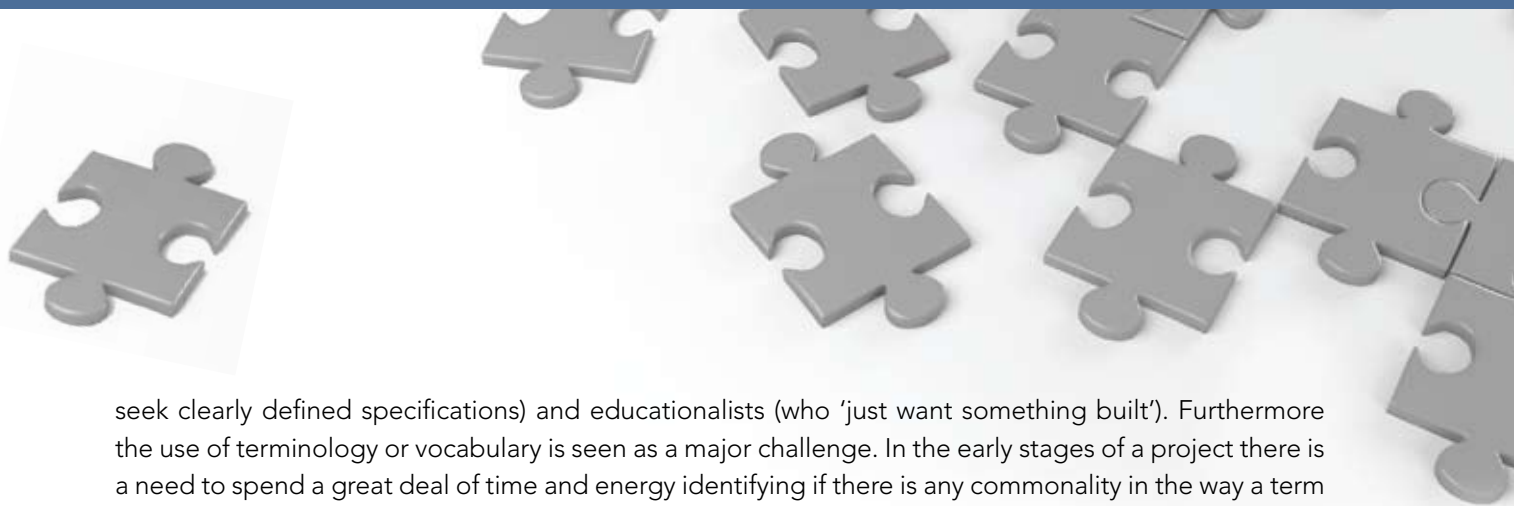
It can be difficult to find evidence of interdisciplinary working because there may not be enough research project drivers to counter the incentives to academic specialisation. Academia remains biased towards disciplinary specialisation, and often rewards esoteric or abstract forms of specialisation. The nature of an academic is to be highly attuned in their thinking, and to cultivate specificity in their vocabulary and their skills. Because of this focus, many academics struggle to – or are unwilling to – relate their discipline to another academic, equally attuned to another discipline, and therefore they are not well equipped to working in interdisciplinary teams. Moreover it is difficult to engage people in interdisciplinary work when they are so busy with disciplinary work. It is hard to prioritise interdisciplinary work unless it is backed with the promise of extra research resources.

Each discipline brings with it particular theoretical perspectives, which help shape and define the discipline. However, one of the complications encountered when trying to adopt a more interdisciplinary approach is that the theoretical perspectives that underpin the different disciplines can be in tension, or even contradiction. Disciplinary perspectives dictate what research is done and how it is to be managed. If the project is truly interdisciplinary, individual practice from the different contributing disciplines should be changed or challenged through the interaction with other disciplines.

TEL research is often viewed as an open or relatively neutral field that draws on a range of different theoretical perspectives. Some believe, consequently, that working in TEL research does not require you to have a strong discipline perspective, that a plurality of approaches is appropriate. (Although that the question of whether TEL research has particular theoretical allegiances remains contentious.) This lack of a specific, defined theoretical basis for the field is problematic as it means that TEL research is perceived by those from more traditional disciplines to be under-theorised and hence immature.

The academic world is often deemed to be remote and disconnected from external world problems. Interdisciplinarity is important in terms of trying to bridge academic and non-academic contexts in order to propose solutions for real-world problems. There is a rather uneasy relationship between the two worlds, especially when for an academic the rewards for being interdisciplinary may be underwhelming, while the risks for working in an interdisciplinary fashion remain higher than those for working in more traditional forms of disciplinary research.

The most commonly identified challenge to interdisciplinary working is that of communication and more specifically the importance of having a shared vision, and clear communication. It is intriguing, therefore, that this common recognition of the problem of communication does not translate more readily into a willingness among disciplinary researchers to find ways to overcome this. Interdisciplinarity is frequently described as being 'hard work' because it involves a long period of developing understanding in each other's language. Indeed, some feel that some research positions exhibited epistemological or methodological differences to such a degree that they cannot sit comfortably together. Others talk about the power relationship within teams; and in particular the dynamics between computer scientists (who



seek clearly defined specifications) and educationalists (who 'just want something built'). Furthermore the use of terminology or vocabulary is seen as a major challenge. In the early stages of a project there is a need to spend a great deal of time and energy identifying if there is any commonality in the way a term is used between separate disciplines. Collaborative writing and discussion have been suggested as ways of helping to find a common language. It may be that engagement with interdisciplinary work may even lead to a change in the way in which individuals view their own discipline-based research. However, the risk of failing to overcome this communication challenge remains a constant threat to interdisciplinarity. This communication challenge stands over and above the more pragmatic challenges presented just by the simple differences in language when working on project teams that cross national borders. Words such as 'scenario', 'intervention' and 'evaluation' have for example very different meanings for educationalists and psychologists, and engineers have different notions of how you evaluate something compared to a psychologist or an educationalist. However once you get beyond the language problem there is a further need to understand the range of paradigms, concepts, theories, methodologies and methods that other disciplines use, and recognise the fact that each discipline evolves and that these paradigms change.

One of the challenges for an academic is to be unafraid of saying 'I don't understand' and hence being amenable to working with others to develop a shared vision and language. This often requires taking some reflective distance to re-affirm understanding. However this is not always possible when working to tight project timescales. Time for development of shared understanding and iterative reflection are not generally built into project timescales, nor indeed would funders necessarily recognise this as a valid set of activities, that required funding and time. This may change in the future. Similar arguments could have been said about the role of evaluation and dissemination activities in projects in the past. However, now most funding bodies recognise (and indeed expect) to see a proportion of research funds dedicated to these activities. The personal elements of communication including 'personal chemistry' and working with others that you respect and trust were also identified as being important to overcome this challenge.

Interdisciplinary working involves collaboration. It is not easy to work together collaboratively, especially if the collaboration requires working between departments, institutions and across geographical borders. When choosing people for a team there has to be a sense of teamwork and camaraderie for the best results either in terms of productivity or reducing conflict. One of the challenges to working in an interdisciplinary context is the development of respect between the different disciplines. Academics can be passionate about the unique nature of their discipline and its approach and may not be inclined to make the effort to try to look at things from another perspective. There are people who find it difficult to understand that it is possible to look at the world in other ways, and that their particular disciplinary tradition is not the only valid way of looking at problems.

Some researchers have the view that TEL research had been dominated by educators, who have tended to treat the computer science component of projects as a service element. Consequently it is difficult for technical partners in TEL research to see what their own technical research agenda might be, because their role becomes more functional. Bringing together people from an education and pedagogy background with technical developers can lead to an impasse, where the technology experts need a clear specification as to what they should design, and the educationalists feel that they can't assess whether something



will work or not until it has been designed and they can evaluate something concrete. Some computer scientists are viewed by some educationalists as seeing education as just context and not being interested in education or educational theories. The computer scientists might argue that the educationalists do not adopt a rigorous enough approach to how the technologies are specified and that they appear more interested in the practical use of the tools. Academics with a learning perspective are often viewed by computer scientists as not respecting the research of the computer scientist, which is often viewed by educationalists as lacking in ethical consideration. Educationalists often feel that the formal specifications handed down from computer science are based on a rarefied or abstract conception of pedagogy.

Research in education is often criticised by those from other research domains, as being methodologically weak, and one of the difficulties is in setting up an appropriate controlled environment where it is possible to demonstrate success. A real problem for TEL research and educational research in general is the identification, demonstration and measurement of such success. One of the challenges is to pull together the outputs or evidence from different viewpoints and disciplines and to find the tools that support interdisciplinarity by evidencing the value it adds.

Accountability systems, such as the Research Assessment Exercise, it could be argued, tend to evaluate according to relatively traditional discipline boundaries, which disadvantages those who are either working in emergent fields or attempting to work across disciplines. There is also a conflict between traditional subject boundaries and interdisciplinary projects with researchers from multiple disciplines, where monitoring and accountability systems which do not recognise the diversity of the project. Lattuca (2001) argues there is a tendency towards academic specialisation, and hence publishing of research outputs is often geared towards disciplinary specialisation. Individual research communities can have strong views about what they see as acceptable as publications and have quite particular ways of reviewing, and there are different cultures of publishing in different disciplines. The journals that are deemed most prestigious don't tend to be interdisciplinary, and if they are interdisciplinary they tend to publish from a particular perspective e.g. technology, or education, or psychology. If a researcher is trying to cut across these disciplines, it can be difficult to find a suitable high-quality publication that not only recognises interdisciplinary research, but also accepts and celebrates it. Breaking through such strongly held beliefs and cultural practices requires bold approaches such as editing a special issue of a journal and foregrounding the interdisciplinary aspects of the work, using alternative communication forms (such as blogs and wikis) to foster debate on the changing nature of academic discourse, or challenging existing metrics for what constitutes 'good' research.

The research process typically consists of an interdisciplinary team working together and producing a set of project outputs. However, the tendency then is for individual disciplinary leads to write for their disciplinary audience, and to selectively include others to collaborate on parts of those papers. Rarely do you get genuine co-constructed shared research papers; firstly because it is perceived to be more prestigious to publish in your own research field, and secondly, because genuinely co-constructing a shared paper can present additional challenges. There is a view that someone who is really working in interdisciplinary research would have to distort their output to get published, and to angle the outputs from a research project more towards one audience than another at different times. Trying to submit an interdisciplinary paper to a journal that is primarily focussed around a particular discipline can cause a number of problems. Articles may get criticised because the methodology is not one usually used in that discipline. Alternatively, the journal might deem the focus of the paper as out of scope.

Journal publications remain crucial to building an academic reputation. One could argue that it is easier to be interdisciplinary as a researcher, whose research reputation has already been established. The types of challenges for academics trying to publish the outputs of interdisciplinary research include: recognising that it is valid to publish in interdisciplinary spaces, identifying appropriate journals to publish in and careful liaising with editors, acknowledging that interdisciplinary contributions are often judged by people with a single disciplinary perspective and hence viewed from a narrower perspective, and needing to publish the results of your interdisciplinary project back in your home discipline to build your disciplinary reputation.

Although journal articles and conference papers are still seen as the main way of disseminating research work, and remain the traditional means of delivering or facilitating peer review, the emergence of new technologies – and, in particular, the participatory web 2.0 technologies – are starting to change the nature of academic discourse in terms of how and where research is disseminated and discussed. The traditional journal paper can seem somewhat outmoded to TEL researchers, who routinely have a multi-faceted digital profile that makes use of a range of social media tools for communicating their research thoughts and findings. Researchers who fit this profile may feel unnecessarily restricted if they are expected to publish primarily in traditional journals.

Academic career structures do not easily favour people doing interdisciplinary research. Funding bodies are often organised along disciplinary lines. In addition, there are relatively fewer interdisciplinary job opportunities, so the career opportunities for interdisciplinary researchers probably remain within established disciplines. Established disciplines can be hostile to interdisciplinary work, which may be seen as parasitic, or lacking rigour. Therefore thinking about how the research project might offer practical support or pastoral care in providing value for their future academic careers is of benefit and will help attract researchers.

The discourse of research councils suggests that they are keen to promote interdisciplinary work. However, it is often difficult for them to manage the process of peer review of proposals. Sometimes an interdisciplinary focus is lost upon grant awarders, who may be from a single discipline. Similarly, funding bodies may prioritise factors other than putting together the ideal interdisciplinary research team, such as fulfilling obligations for ring-fenced funding or strategic development. When applying for funding, interdisciplinary teams should ensure that they make the best possible case, paying special attention to the particular features of interdisciplinary research.

Strategies for success

The success of interdisciplinary research is dependent on a number of factors, including: strong project leadership, an effective and supportive working culture across the team, and trusting relationships within the team. Conflict can result from having a project leader who does not have the skills to foster interdisciplinary practice, promotes their own research discipline over others, or does not understand the different disciplines contributing to the research. Common success strategies include the importance of having a shared vision, the need for good leadership, effective and frequent communication channels and the need to ensure that there is mutual trust and developed of an understanding of individual researchers. It is also true that success may come out of conflict, particularly in the early stages of bringing together a project team. The team members need to be flexible in their approach to work through the conflict with researchers from other disciplines. Successful collaboration to achieve this mix of project coherence and creativity is largely about leadership. The research leader needs to be someone who can draw a team together of different disciplinary perspectives, and inspire them with a vision that helps them overcome obstacles, and indeed the most valuable outcomes of an interdisciplinary project are the ones you had not anticipated in advance. Success also may depend more on the personal characteristics of the individual than it does upon their interdisciplinarity, and selecting individuals who can work as part of the team and recognising that their particular disciplinary approach is not the only valid way is important. It may be taken as a sign of successful interdisciplinary collaboration if people come to the discussion with their own perspectives, collaborate and leave with new perspectives. If they leave with their own perspectives intact the collaboration has failed.

Conclusion

This report has provided an overview of interdisciplinarity and its role in TEL research. It has considered both the benefits and challenges of doing interdisciplinary research. Our intention with this report has been to explore the nature of interdisciplinarity in a TEL research context, and to identify strategies for supporting, communicating and documenting interdisciplinarity.

It is evident that interdisciplinarity is a core feature of TEL research. TEL researchers are drawn from across a broad range of disciplines and bring with them a rich variety of theoretical perspectives and methodologies. These have the potential to be harnessed to provide real insights into some of the challenging research questions in contemporary TEL research. However, this multiplicity also brings challenges, such as a lack of a shared coherent discourse, tensions and power struggles between the different subject domains and a lack of perceived rigour and credibility.

In our work we have identified a number of perceived benefits of undertaking interdisciplinary work in TEL research. These include capitalising on the breadth of different theoretical and methodological perspectives to address key research challenges, working in interdisciplinary teams results in researchers broadening their research perspectives – helps them become aware of additional literatures to those that they are most familiar with and having others to challenge ideas. The nature of teams, the need for a core shared vision, mechanisms in place to support capacity building within the team, strong leadership, clear, effective and frequent communication mechanisms; and, most importantly, a sense of shared trust and ownership are key strategies for success. Tensions, however, are also evident: it is often difficult to develop a shared common language, and building a strong team requires time and trust. Institutional and

professional barriers are also evident. Single discipline research is generally more highly regarded and much interdisciplinary research is often accused of being methodologically muddled or less rigorous.

In terms of supporting, communicating and documenting interdisciplinarity it is evident that a number of strategies can be adopted. Firstly, and perhaps foremost, is the need to ensure that there is effective communication across the team. The different perspectives amongst team members need to be articulated and interrogated in light of the research question being addressed. An ongoing iterative process of dialogic engagement and critical reflection is needed, so that the team can come to some degree of shared understanding and consensus. The time and effort needed to achieve this should not be underestimated. Technologies have the potential to act as powerful mediating artefacts in this process, by providing mechanisms for sharing and documenting understanding. They can act as a prompt for debate and as a digital trial of the discourse within the team. The choice of which technologies to use will have an impact on the nature of the discussion and the collaboration. Secondly, team dynamics are clearly important. The project lead needs to be sensitive to group dynamics and help foster a culture of trust and shared enterprise. The articulation of a common vision for the research right at the start of the project can help with this, as can the ongoing dialogic exchange discussed above. Thirdly, capacity building is likely to be important, both in terms of helping individuals to develop the skills and competences they need to adopt interdisciplinary approaches and to use new technologies as effective tools.

Through our review of the literature and the interviews conducted with TEL researchers, we have gained valuable insights into the nature of interdisciplinarity in TEL research; highlighting both the benefits and challenges, as well as a number of strategies that can be adopted to promote better interdisciplinary research. However, a number of overarching policy, professional and institutional issues remain. If we agree that interdisciplinarity is essential for tackling TEL research challenges, then existing theoretical and practical barriers will need to be overcome. We conclude by posing a series of questions around mechanisms for supporting and promoting interdisciplinary approaches:

- How is team-work best supported in an interdisciplinary setting?
- How can we make best use of the technology to support good communication and collaboration?
- What kind of safeguards might help ensure that interdisciplinary TEL research projects remain focused?
- Are there some research topics that lend themselves more readily to interdisciplinary research in TEL than others?
- Is interdisciplinarity better suited to longer-term (or larger-scale) research projects?
- Do new disciplines arise from the combinations of different disciplines, or should these all be referred to as 'interdisciplinary'?



ISBN: 978-0-85473-908-0